

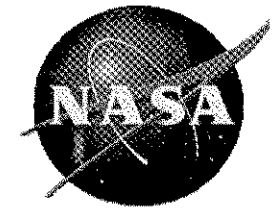
STI 10-040



# **Precursor Analysis for Flight- and Ground- Based Anomaly Risk Significance Determination**

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NASA Office of Safety and Mission Assurance**

**Presented at  
Space System Risk Management Symposium  
El Segundo CA, April 2010**



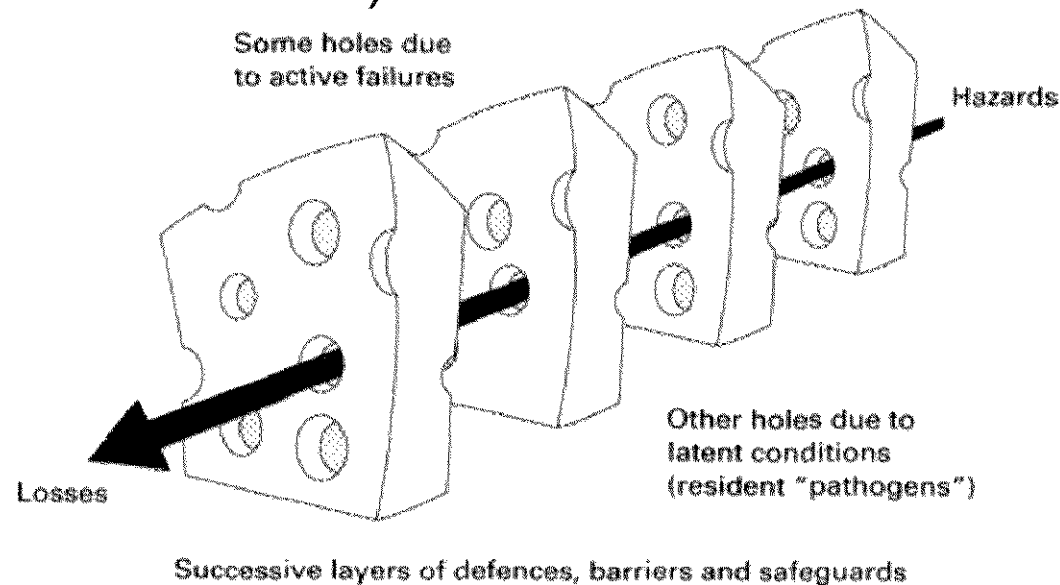
## Need for Precursor Analysis

- **CAIB Final Report (October 2003)**
  - **Section 6.1:** “The Board notes that although there is a process for conducting hazard analyses when the system is designed and a process for re-evaluating them when a design is changed or the component is replaced, no process addresses the need to update a hazard analysis when anomalies occur.”
  - **Section 7.1:** “Signals of potential danger, anomalies, and critical information should, in principle, surface in the hazard identification process and be tracked with risk assessments supported by engineering analyses.”
  - **Finding 7.4-5:** “Risk information and data from hazard analyses are not communicated effectively to the risk assessment and mission assurance processes. The Board could not find adequate application of a process, database, or metric analysis tool that took an integrated, systemic view of the entire Space Shuttle system.”
- **2006 ASAP Annual Report in regards to Safety Management**
  - “the ASAP found that ...the Agency, could better gauge the likelihood of losses by developing leading indicators, rather than continuing to depend on lagging indicators.”

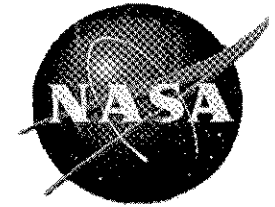
# “Swiss Cheese” Concept of Precursor Analysis



- Ordinarily, accidents are prevented by a combination of barriers (human and hardware system features to prevent accidents)

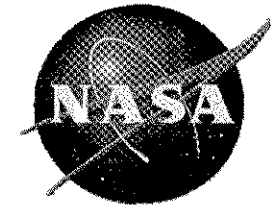


- Complete pathway through cheese represents accident
- Precursor conceived as partial pathway through the holes in Swiss cheese
- Precursor analysis then corresponds to learning about existence and size of holes

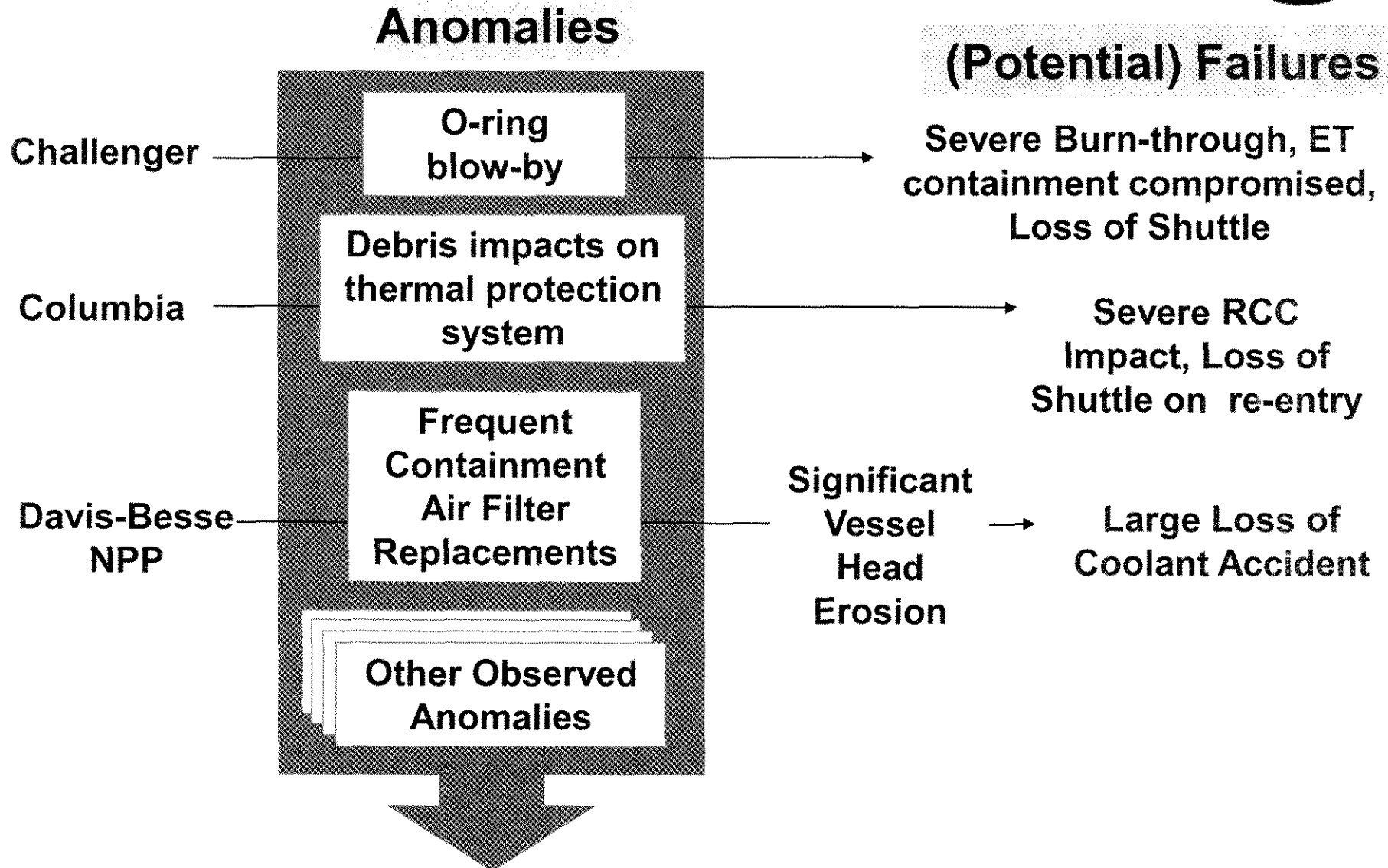


## **“Precursor” Definition**

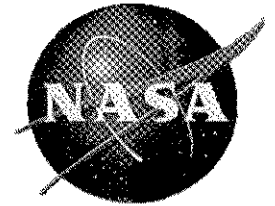
- Definition of a “precursor”
  - An indication of a problem with the potential to recur with more severe consequences
- Key Attributes:
  - Observation indicates some failure mechanism
  - Same mechanism could occur again
  - The consequences could be more severe than what has been experienced



## Well-Known Precursors



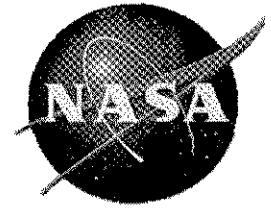
How do we focus on *risk-significant* anomalies?



# Examples of Types of Precursors

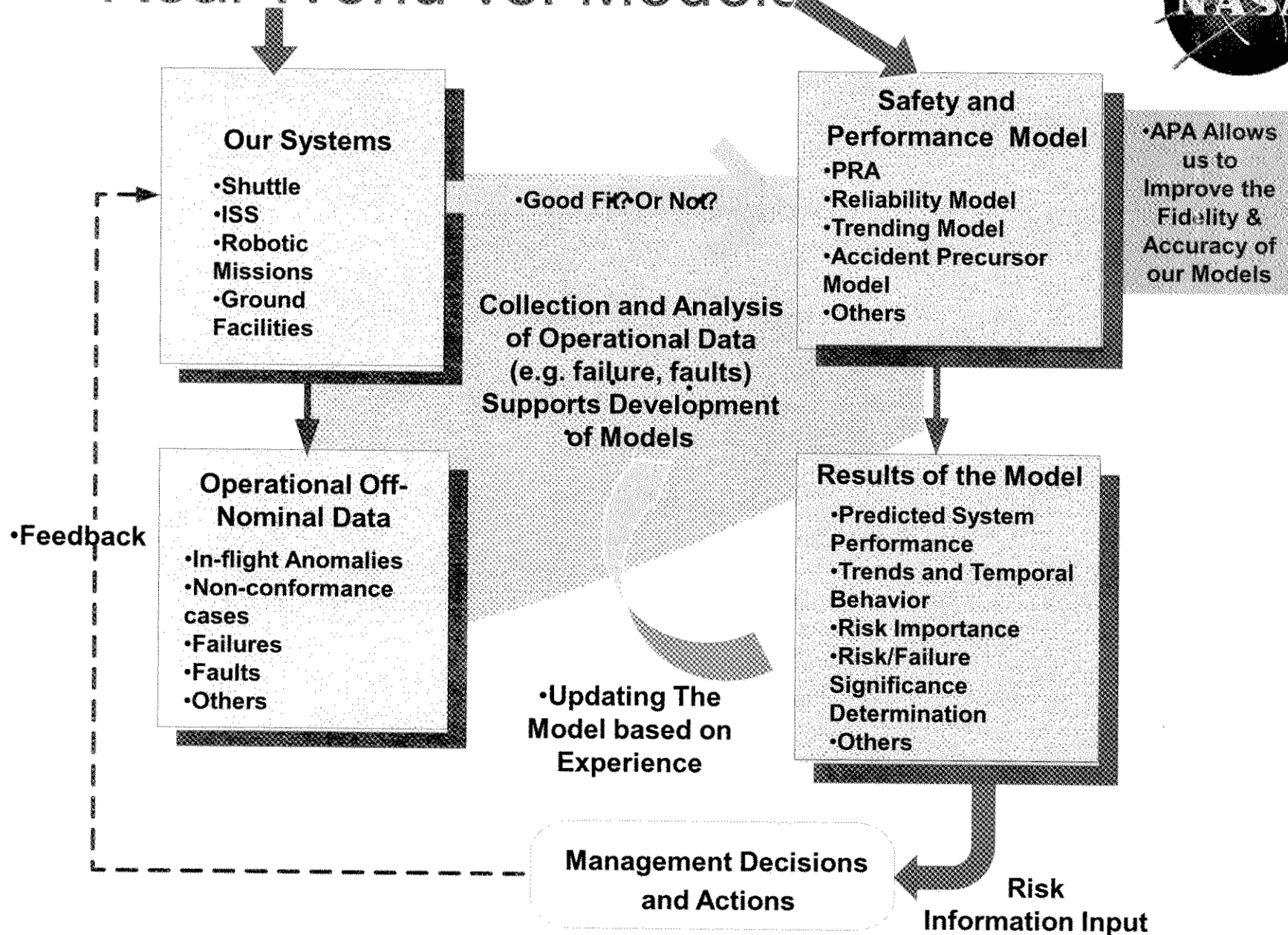
- A near-miss because of chance or an opportune mitigation
- Faults that can become failure conditions without correction
- Unexpected trend in test, operation, or maintenance
- Unexpected effects from aging of equipment
- Common causes of faults or deteriorations

# Accident Precursor Analysis

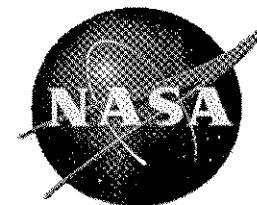


- Establishes a systematic process for evaluation of flight and test anomalies
  - Risk-based evaluation of failure mechanisms
  - Triggered by actual flight/test experience
  - Emphasizes 'imagination' through generalization
- Provides insight into safety performance
  - Identifies safety-related system vulnerabilities
  - Indicates trends in safety performance
- Makes safety analysis more experience-based
  - Triggers review/modification of safety models based on analysis findings
    - Completeness of represented failure modes
    - Failure probabilities and influencing factors

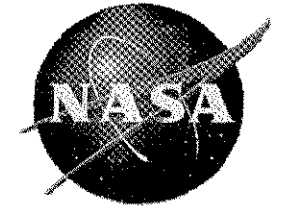
# Real World vs. Models







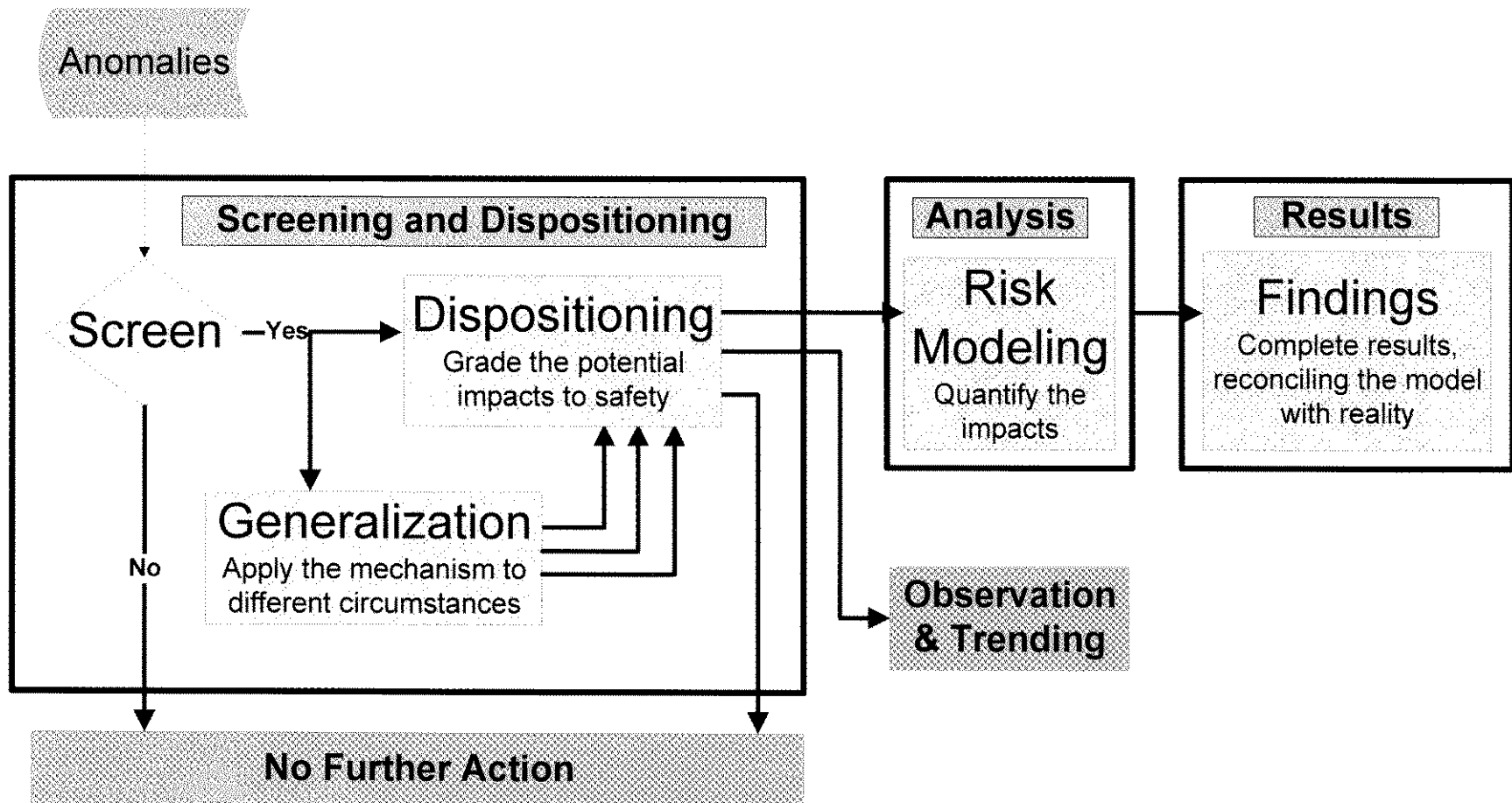
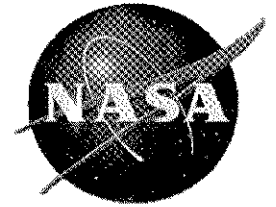
# **Overview of NASA's Accident Precursor Analysis Technical Approach**

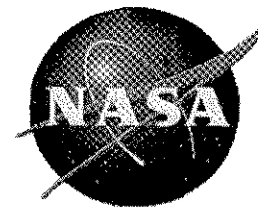


## Operational Definition of Precursor

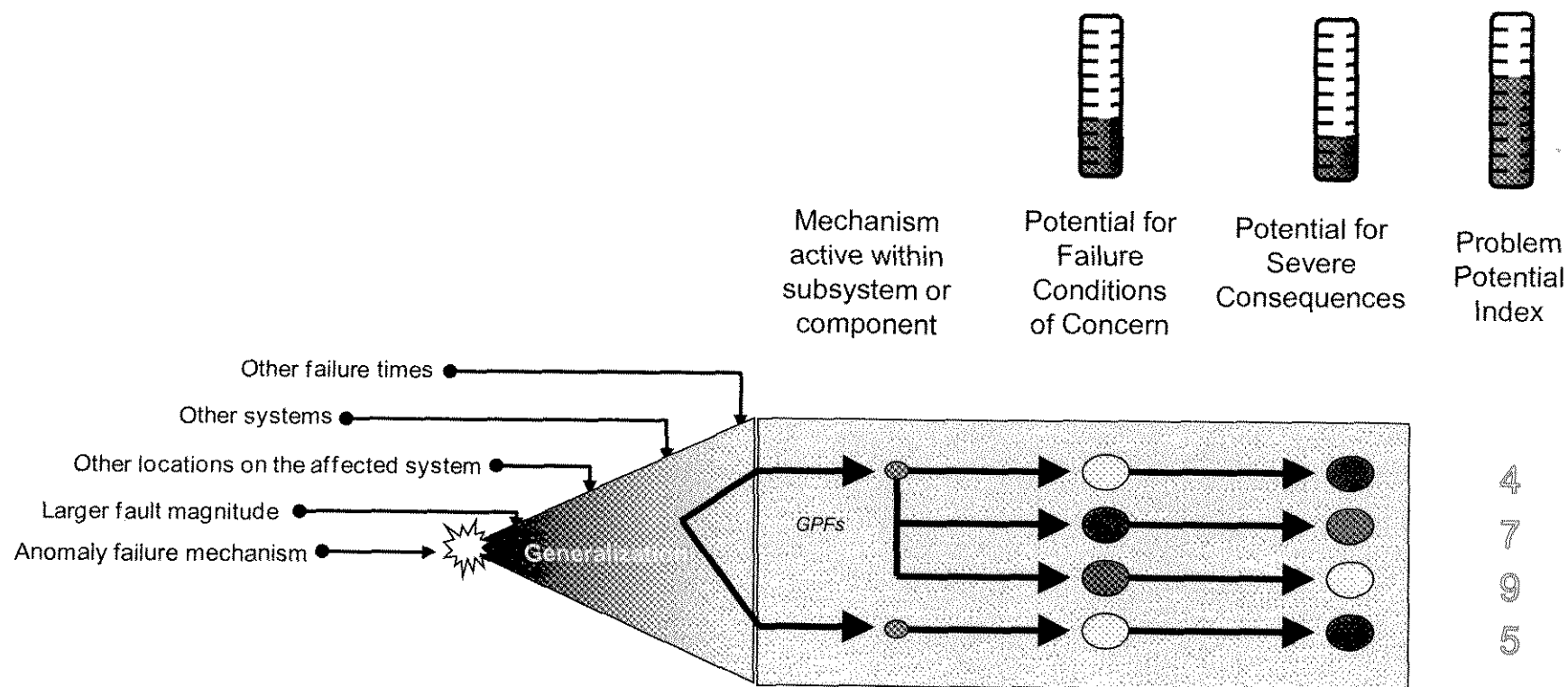
- Historically, precursor analysis has been focused on failures, e.g., at Nuclear Regulatory Commission
- NASA process extends focus to anomalies
  - NASA's databases contain mostly anomalies (a defect, fault, or other deviation)
  - NASA has a stronger incentive to prevent any failure due to fewer barriers in its space systems
- **Operational definition of precursors:**  
Anomalies that upon evaluation are determined to indicate a failure mechanism that may pose a significant degree of risk

# NASA APA Process





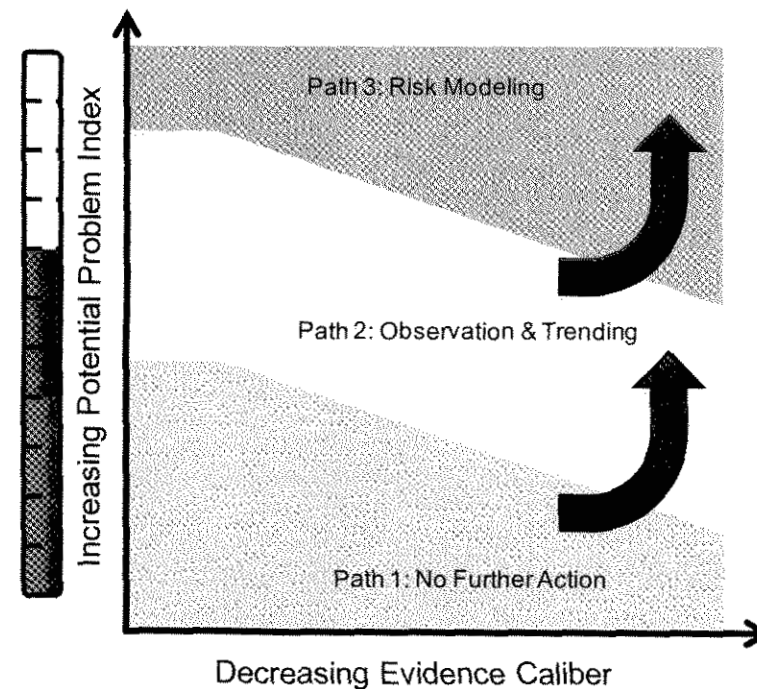
# Anomaly Dispositioning Model

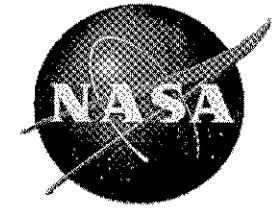




## Disposition Pathways

- Anomalies without obvious risk- or reliability implications are removed from consideration using rules-of-thumb
- Failure mechanisms of screened-in anomalies are determined and generalized
- Dispositioning is based on
  - Generalized problem potential
  - Evidence caliber



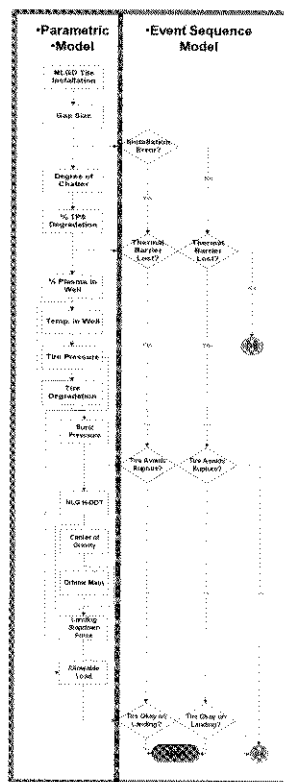


# Probabilistic Analysis

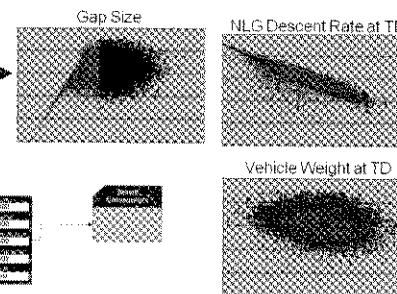
- **Parametric Probabilistic Modeling & Risk Significance Assessment**
  - Quantify the risk potential for anomalies and GPFs dispositioned for Risk Modeling

- Provides a rigorous assessment of the quantified risk significance of the failure mechanism acting within the system while also highlighting parametric uncertainties of the accident sequences that should be further investigated

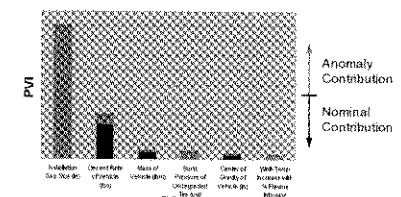
## Parametric Probabilistic Modeling (PPM)



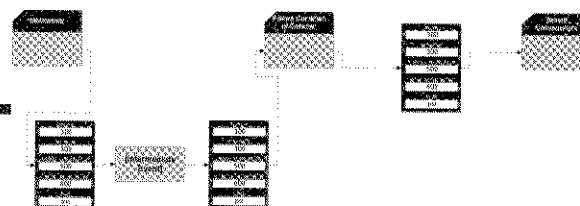
## PPM Results



## Anomaly Risk Importance & Parameter Vulnerability Analysis

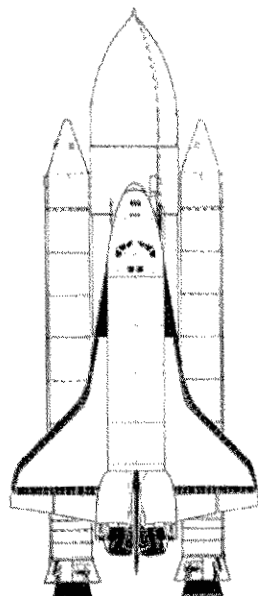


## Scenario Development for Events Dispositioned for Risk Modeling

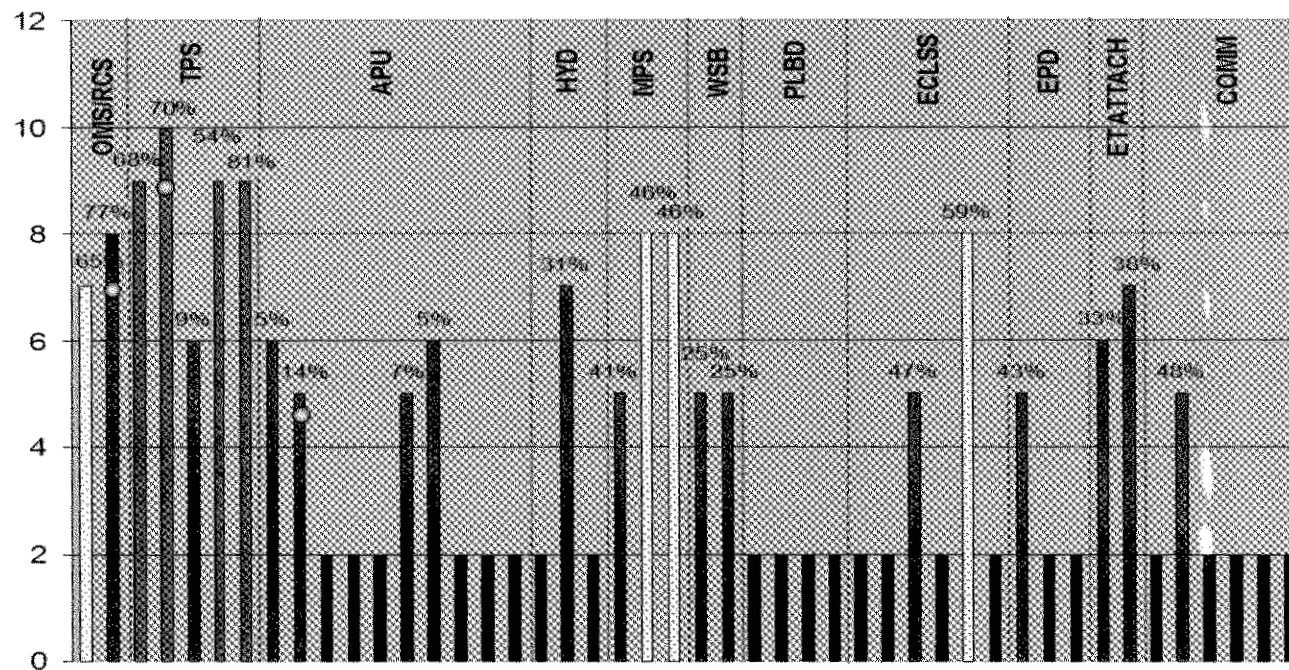
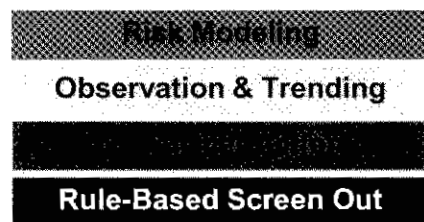


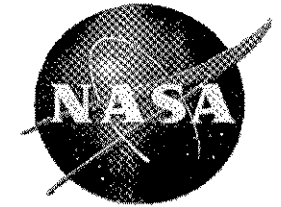


# Example Space Shuttle Working Session Results



2005	2006	2007	2008
STS-114	STS-116, STS-115, STS-121	STS-120, STS-118, STS-117	STS-124, STS-123, STS-122





## Closing Remarks

- **Accident Precursor Analysis (APA) has been used by other govt agencies with positive results (e.g., NRC)**
- **Intended to be applied outside the normal problem resolution cycle**
- **Development of NASA APA methodology will continue in 2010**